U.S. Patent Application No: 10/529,804





# PHOSPHORUS-DEOXIDISED COPPER (HIGH RESIDUAL PHOSPHORUS)

# Cu-DHP

Commercially-pure copper which has been deoxidised with phosphorus to leave a relatively high residual content. It is not susceptible to hydrogen embrittlement. The conductivity of this type of copper is relatively low on account of the high phosphorus content. The raw material is normally available as cakes, slabs and billets which are hot and cold worked into wrought forms.

## COMPOSITION (weight %)

| | |
|---|---|
| Cu (+ Ag) | 99.85 min. |
| P | 0.013 - 0.050 |

## 1 SOME TYPICAL USES

**Architectural and Building:**

Tubes for hot and cold water services, gas and heating installations, both buried and above ground; soil and waste pipes; storage tanks, cisterns and cylinders; air conditioners.

**Mechanical:**

Suitable for any equipment involving heating in reducing gases either during joining processes or in service; evaporator and heat exchanger tubes; steam, air, water and oil lines; automobile radiators.

**Chemical:**

Stills, vats, autoclaves and general coppersmithing involving welding; tubes for relatively non-corrosive liquids and gases and for refrigeration.

**Electrical:**

Anodes for electroplating and electroforming from acid sulphate baths.

## 2 PHYSICAL PROPERTIES

| | Metric Units | English Units |
|---|---|---|
| 2.1 Density at 20 °C *68 °F* | 8.9 g/cm³ | 0.321 lb/in³ |
| 2.2 Melting point | 1 083 °C | 1 981 °F |
| 2.3 Coefficient of thermal expansion (linear) at: | | |
| — 253 °C *— 423 °F* (1) | 0.000 000 3 per °C | 0.000 000 17 per °F |
| — 183 °C *— 297 °F* (1) | 0.000 009 5 » » | 0.000 005 28 » » |
| — 191 to 16 °C *— 312 to 61 °F* (2) | 0.000 014 1 » » | 0.000 007 83 » » |
| 25 to 100 °C *77 to 212 °F* (2) | 0.000 016 8 » » | 0.000 009 33 » » |
| 20 to 200 °C *68 to 392 °F* (3) | 0.000 017 3 » » | 0.000 009 61 » » |
| 20 to 300 °C *68 to 572 °F* (4) | 0.000 017 7 » » | 0.000 009 83 » » |
| 2.4 Specific heat (thermal capacity) at: | | |
| — 253 °C *— 423 °F* (2) | 0.003 1 cal/g °C | 0.003 1 Btu/lb °F |
| — 150 °C *— 238 °F* (2) | 0.067 4 » | 0.067 4 » |
| — 50 °C *— 58 °F* (2) | 0.086 2 » | 0.086 2 » |
| 20 °C *68 °F* (2) | 0.092 1 » | 0.092 1 » |
| 100 °C *212 °F* (2) | 0.093 9 » | 0.093 9 » |
| 200 °C *392 °F* (2) | 0.096 3 » | 0.096 3 » |
| 2.5 Thermal conductivity at: | | |
| 20 °C *68 °F* | 0.70 - 0.87 cal cm/cm² s °C | 169 - 211 Btu ft/ft² h °F |

*continued overleaf*

*INDEX NUMBERS RELATE TO LITERATURE REFERENCES (see page 10); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE*

Prepared by
CONSEIL INTERNATIONAL POUR LE DEVELOPPEMENT DU CUIVRE (CIDEC)
8, rue du Marché - GENEVE

DATA SHEET No. A 6
Cu-DHP

## 2 PHYSICAL PROPERTIES (continued)

| | Metric Units | | English Units | |
|---|---|---|---|---|
| **2.6** Electrical conductivity (volume) at: | | | | |
| 20 °C *68 °F* (annealed or cold worked) | 41 - 52 | m/ohm mm² | 70 - 90 % IACS | |
| **2.7** Electrical resistivity (volume) at: | | | | |
| 20 °C *68 °F* (annealed or cold worked) | 0.025 - 0.019<br>2.5 - 1.9 | ohm mm²/m<br>microhm cm | 15 - 12<br>0.97 - 0.75 | ohms (circ mil/ft)<br>microhm in |
| **2.8** Temperature coefficient of electrical resistance at: [a] | | | | |
| 20 °C *68 °F* (annealed or cold worked)<br>applicable over range from 0 to 100 °C *32 to 212 °F* | 0.002 75 per °C (70 % IACS)<br>0.003 54 » » (90 % IACS) | | 0.001 53 per °F (70 % IACS)<br>0.001 96 » » (90 % IACS) | |
| **2.9** Modulus of elasticity (tension) at 20 °C *68 °F*: | | | | |
| annealed | 12 000 | kg/mm² | 17 000 000 | lb/in² |
| cold worked | 12 000 - 13 500 | » | 17 000 000 - 19 000 000 | » |
| **2.10** Modulus of rigidity (torsion) at 20 °C *68 °F*: | | | | |
| annealed | 4 500 | kg/mm² | 6 400 000 | lb/in² |
| cold worked | 4 500 - 5 000 | » | 6 400 000 - 7 000 000 | » |

(a)— The temperature coefficients of resistance given can be used for calculating resistances within the temperature range shown, but these relate only to calculations based on a reference temperature of 20 °C *(68 °F)*.

— The temperature coefficient of resistance of copper can be assumed to be directly proportional to the conductivity value and the figures given above have been calculated on the basis that copper of 100 % IACS conductivity at 20 °C *(68 °F)* has a temperature coefficient of resistance of 0.003 93 per °C *(0.002 18 per °F)*. Temperature coefficients of resistance for copper with a conductivity value within the range shown above may be calculated in the same manner.

## 3 FABRICATION PROPERTIES

The information given in this table is for general guidance only, since many factors influence fabrication techniques.

The values shown are approximate only, since those used in practice are dependent upon form and size of metal, equipment available, techniques adopted and properties required in the material.

| | Metric Units | English Units |
|---|---|---|
| **3.1** Casting temperature range | 1 140 - 1 200 °C | 2 085 - 2 190 °F |
| **3.2** Annealing temperature range | 250 - 650 °C | 480 - 1 200 °F |
| Stress relieving temperature range | 200 - 250 °C | 390 - 480 °F |
| **3.3** Hot working temperature range | 750 - 950 °C | 1 400 - 1 750 °F |
| **3.4** Hot formability | Good | |
| **3.5** Cold formability | Excellent | |
| **3.6** Cold reduction between anneals | 95 % max. | |
| **3.7** Machinability: | See General Data Sheet No. 2 | |
| Machinability rating (free-cutting brass = 100) | 20 | |
| **3.8** Joining methods: | See General Data Sheet No. 3.1 | |
| Soldering | Excellent | |
| Brazing | Excellent | |
| Oxy-acetylene welding | Good | |
| Carbon-arc welding | Good | |
| Gas-shielded arc welding | Excellent | |
| Coated metal-arc welding | Not recommended | |
| Resistance welding: spot and seam | Fair | |
| butt | Good | |

## 5.1 MECHANICAL PROPERTIES AT ROOM TEMPERATURE [a]

### 5.1.1 Typical Tensile Properties and Hardness Values - Metric Units

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.

For a given temper, individual elongation values may show some variation below or above the typical values indicated.

| Form | Temper | Tensile Strength kg/mm² | Proof Stress 0.2 % offset kg/mm² | Elongation % | Elongation gauge length | Hardness Brinell | Hardness Vickers | Shear Strength kg/mm² | Typical Size Related to Properties Shown [b] |
|---|---|---|---|---|---|---|---|---|---|
| Plate Sheet Strip | Annealed | 22 | 5 | 48 | $5.65\sqrt{S_o}$ | 45 | 50 | 16 | — |
| | Hot Rolled | 23 | 8 | 40 | $5.65\sqrt{S_o}$ | 55 | 60 | 16 | — |
| | Typical Cold Worked Tempers | 27 | 18 | 25 | $5.65\sqrt{S_o}$ | 75 | 80 | 18 | 0.2 - 10 mm thick |
| | | 32 | 27 | 12 | $5.65\sqrt{S_o}$ | 90 | 100 | 19 | 0.2 - 6 mm thick |
| | | 38 | 34 | 6 | $5.65\sqrt{S_o}$ | 105 | 115 | 20 | 0.2 - 1.5 mm thick |
| Rod | Annealed | 22 | 5 | 45 | $5.65\sqrt{S_o}$ | 45 | 50 | 16 | — |
| | Typical Cold Worked Tempers | 28 | 19 | 20 | $5.65\sqrt{S_o}$ | 75 | 80 | 18 | 6 - 40 mm diam. or up to 1 250 mm² area |
| | | 34 | 28 | 10 | $5.65\sqrt{S_o}$ | 95 | 105 | 19 | 6 - 20 mm diam. or up to 300 mm² area |
| Tube | Annealed | 24 | 6 | 45 | $5.65\sqrt{S_o}$ | 45 | 50 | 16 | — |
| | Typical Cold Drawn Tempers [c] | **27** | **18** | **30** | $5.65\sqrt{S_o}$ | **75** | **80** | **18** | 10 - 200 mm O.D. up to 10 mm wall |
| | | **32** | **27** | 15 | $5.65\sqrt{S_o}$ | **90** | **100** | **19** | 10 - 100 mm O.D. up to 6 mm wall |
| | | 35 | 30 | 8 | $5.65\sqrt{S_o}$ | 100 | 110 | 20 | 10 - 50 mm O.D. up to 2 mm wall |
| | | 38 | 35 | 6 | $5.65\sqrt{S_o}$ | 105 | 115 | 20 | up to 25 mm O.D. up to 1 mm wall |
| Forgings | Hot Worked | 23 | 6 | 35 | $5.65\sqrt{S_o}$ | 50 | 55 | 16 | — |
| Sections / Shapes | Hot Worked | 24 | 8 | 35 | $5.65\sqrt{S_o}$ | 50 | 55 | 16 | — |
| | Typical Cold Worked Tempers [d] | 27 | 18 | 20 | $5.65\sqrt{S_o}$ | 75 | 80 | 16 | — |
| | | 32 | 27 | 10 | $5.65\sqrt{S_o}$ | 90 | 100 | 19 | — |

(a) It will be noted that tables 5.1.1, 5.1.2 and 5.1.3, giving typical tensile properties and hardness values in Metric, English and American units, respectively, are not directly comparable. This is because the properties quoted reflect to some extent the metalworking techniques and specification practices of the countries concerned.

(b) It is possible to obtain sizes outside the ranges given in this column, but information on their mechanical properties should be obtained from the metal suppliers.

(c) Tubes for condensers and heat exchangers are generally supplied only to the tempers whose representative mechanical properties are printed in **bold type.**

(d) The mechanical properties will be largely dependent upon the complexity and cross-section of the product.